



## Temperatur stabilisering ved brug af faseskiftende materiale - PCM

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*Publication date:*  
2010

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*Citation (APA):*

Rode, C., & Gunner, A. (2010). *Temperatur stabilisering ved brug af faseskiftende materiale - PCM*. Paper presented at Danvak Dagen 2010, DTU, Kgs. Lyngby.  
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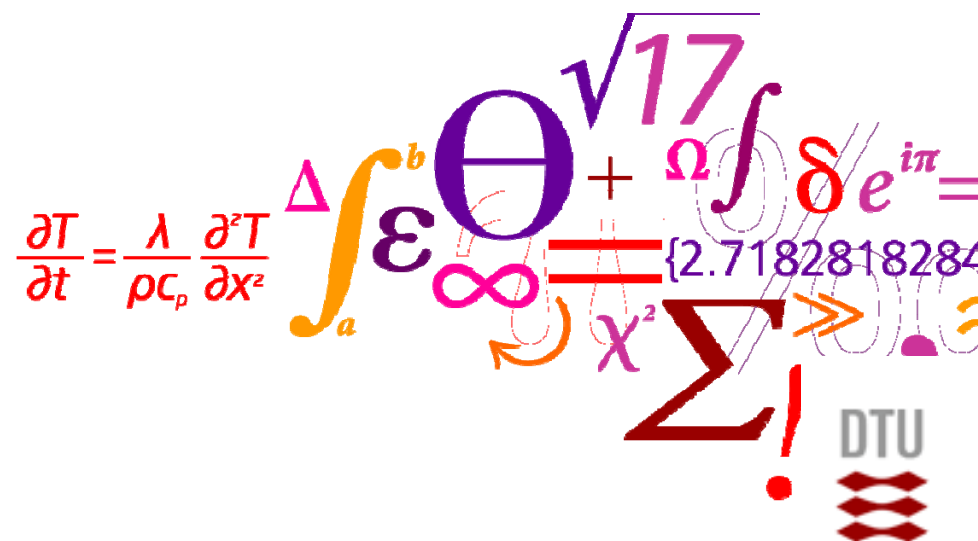
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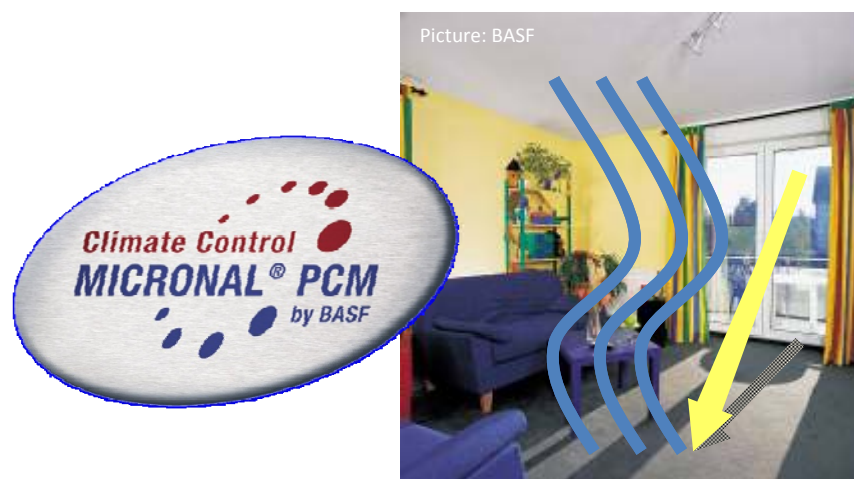
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# Temperatur stabilisering ved brug af faseskiftende materiale - PCM

Carsten Rode & Amalie Gunner



# Phase Change Materials - latent varme lagring for at opnå større komfort i fx et kontor



$$\frac{\partial T}{\partial t} = \frac{\lambda}{\rho c_p} \frac{\partial^2 T}{\partial x^2}$$

$$\int_a^b \epsilon \infty = \{2.7182818284\}$$

$$\delta e^{i\pi} =$$

$$\chi^2$$

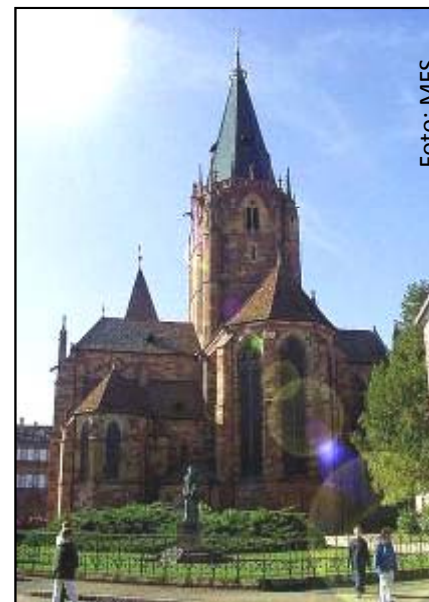
$$\Sigma$$

# Hvad er formålet med PCM?

Modern lightweight architecture



Heavy old building



PCM is the **ONLY** technology, which is able to **STOP temperature increase** at indoor application, without causing energy expenses

# PCM in summer - Insulation in winter

- In winter thermal insulation reduces heat loss through the walls

- In summer most energy entry is through the window

- Effective temperature control via:

- Heat storage

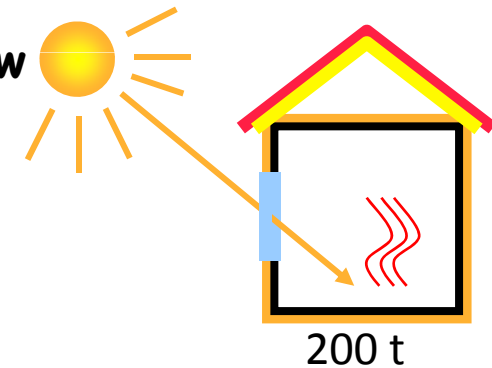
- Shade

- Night ventilation

- Insulation



= resulting  
interior  
temperature



# Heat storage: two types

**Latent varmelagring**

**Phase transition**

“Melting/Crystallization heat”

Ice-Water:  $\Delta H = 333 \text{ kJ/kg}$

**at 0C**

333 kJ/kg



**Sensibel varmelagring**

**Temperature difference**

“Heat capacity”

Water:  $c_p \approx 4.2 \text{ kJ/kg} \cdot \text{K}$

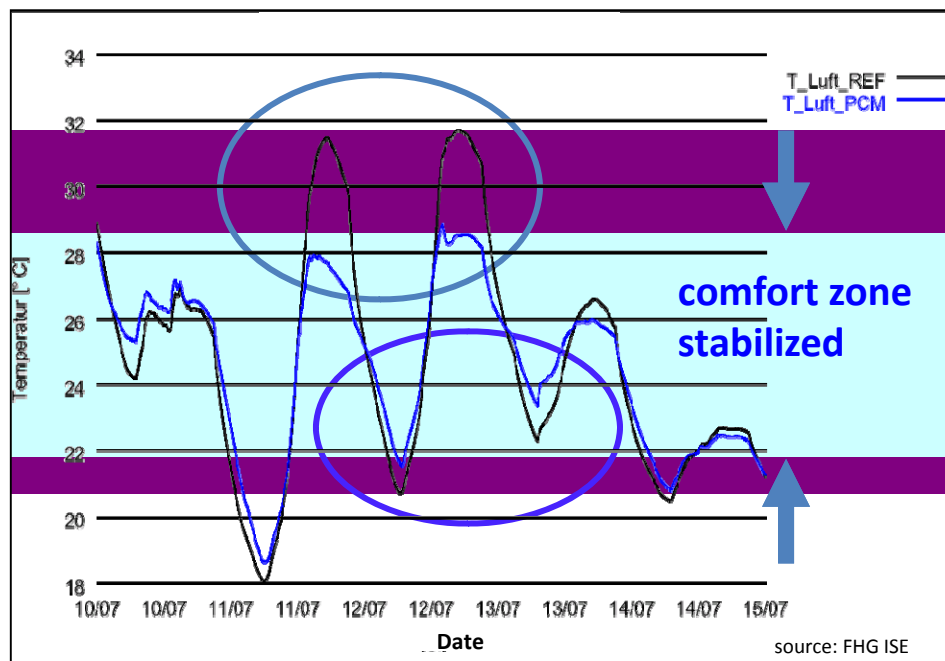
**1C → 80C**

332 kJ/kg

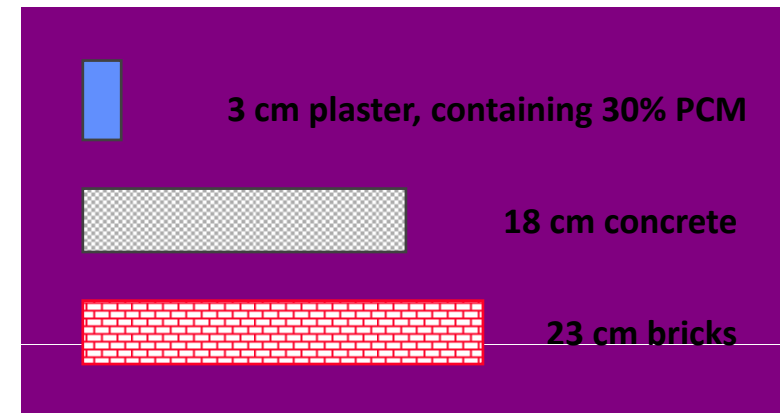
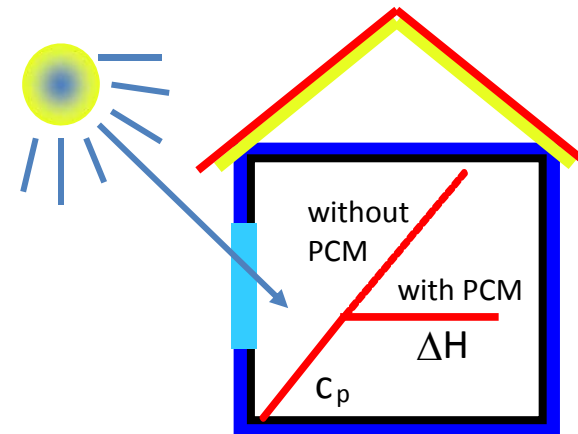


# Use of PCM in construction

Comparison Air Temperatures [°C]

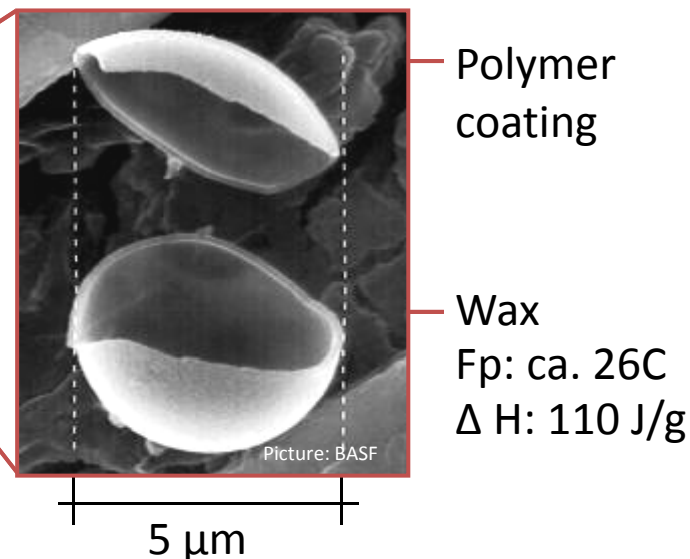
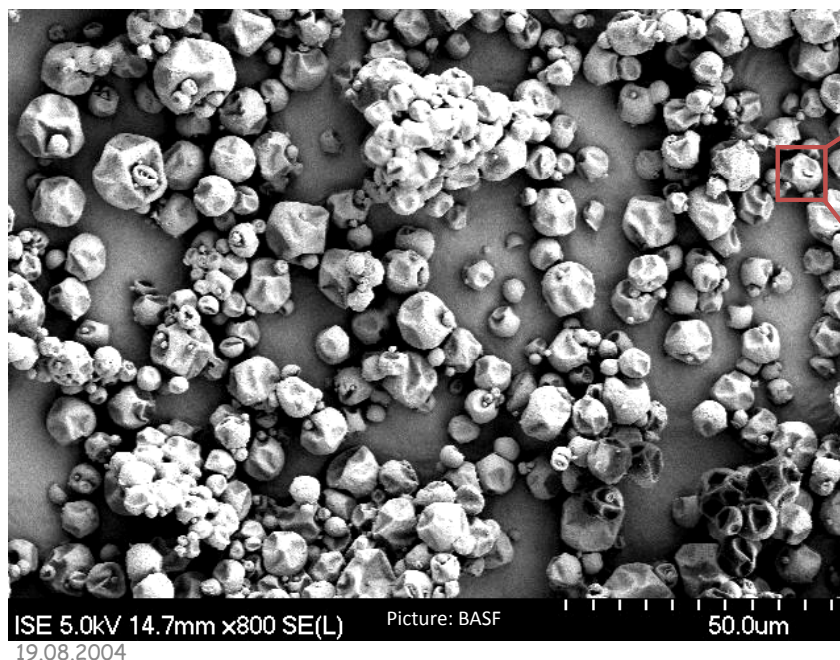


- PCM traps heat from room
- Recrystallisation to recharge PCM



# Microcapsules as packaging

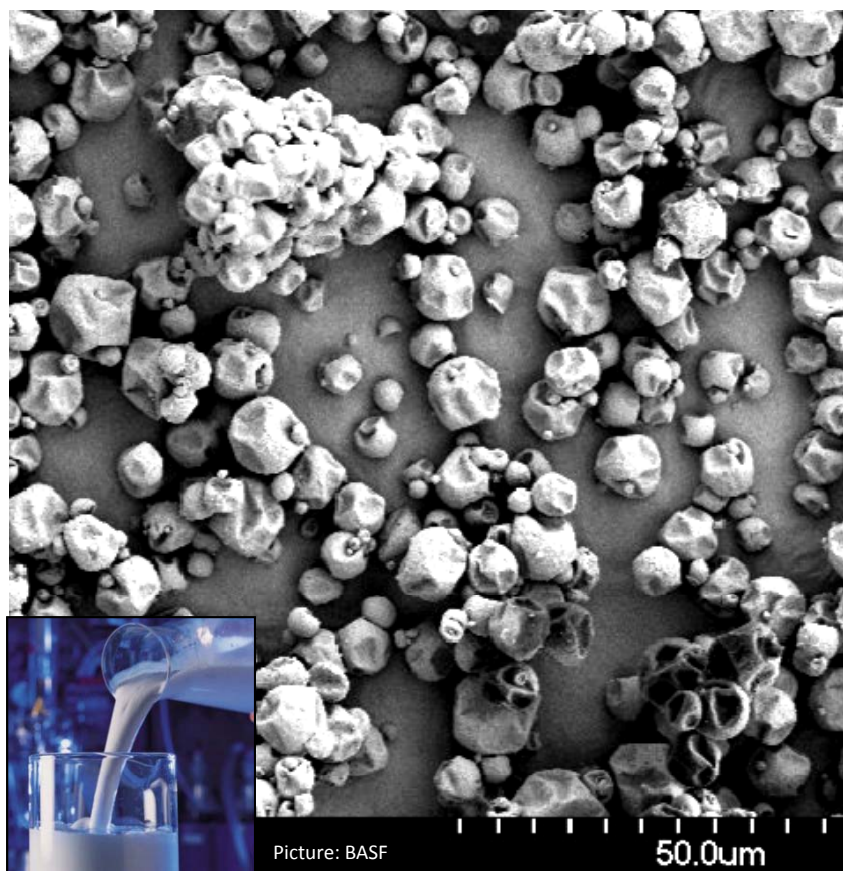
- Building materials soaked with PCM can result in exudation.
- Microcapsuled latent heat stores overcome this problem.





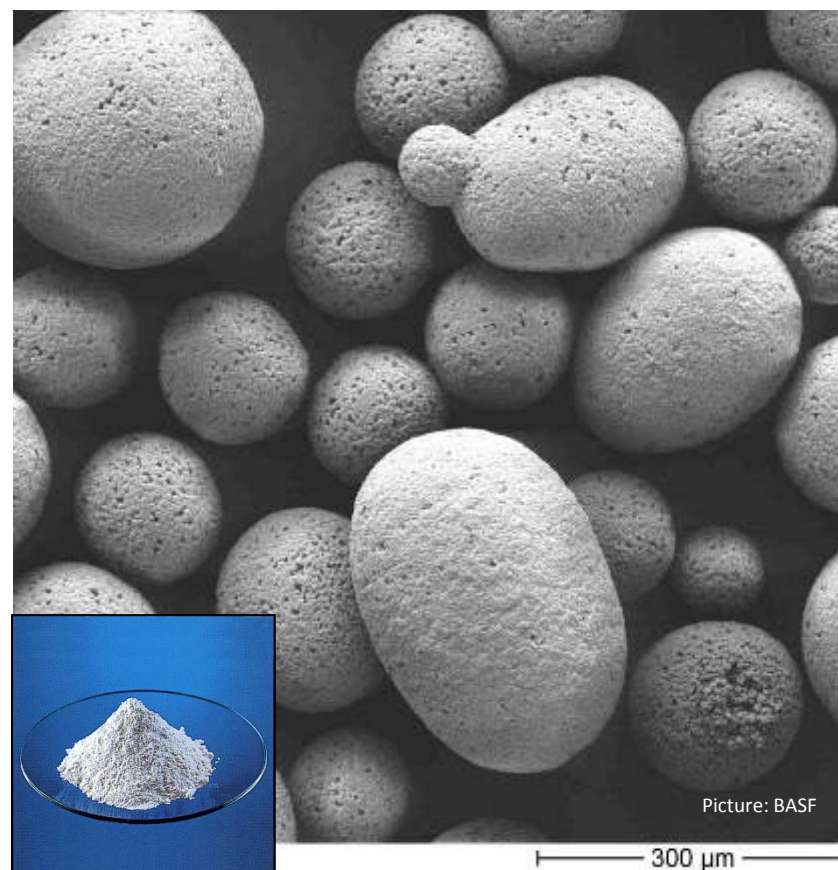
# Material background - Micronal<sup>®</sup> PCM

## Liquid

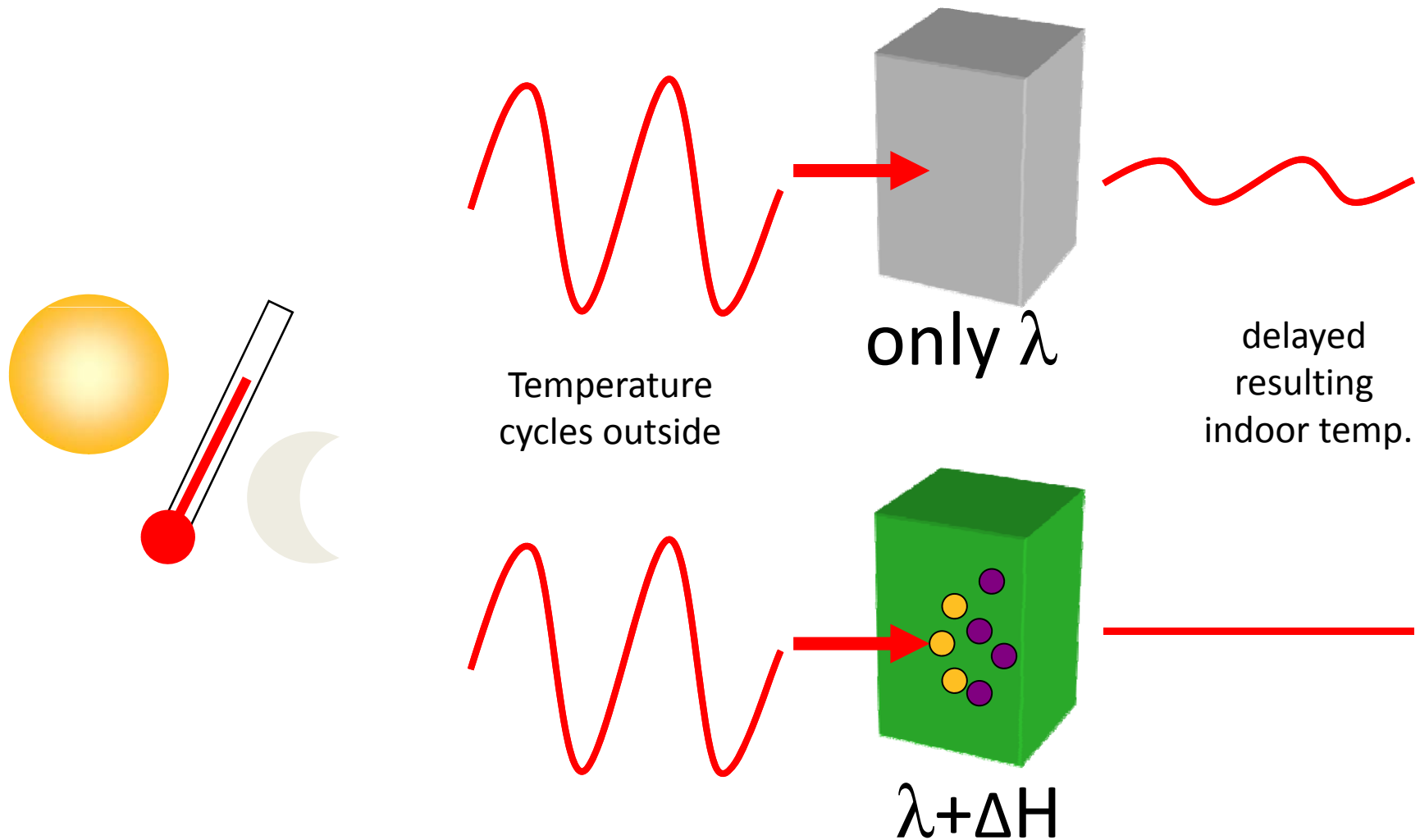


19.08.2004

## Powder



# PCM - Aircrete Insulation AND Thermal Capacity



# Ready-to-use Micronal® PCM SmartBoard™ 23/26

Length	2,00 m
Width	1,25 m
Thickness	15 mm
Weight	11,5 kg/m <sup>2</sup>
PCM content	approx. 3 kg dry/m <sup>2</sup>
Heat capacity (latent)	min. 330 kJ/m <sup>2</sup>



Picture: BASF

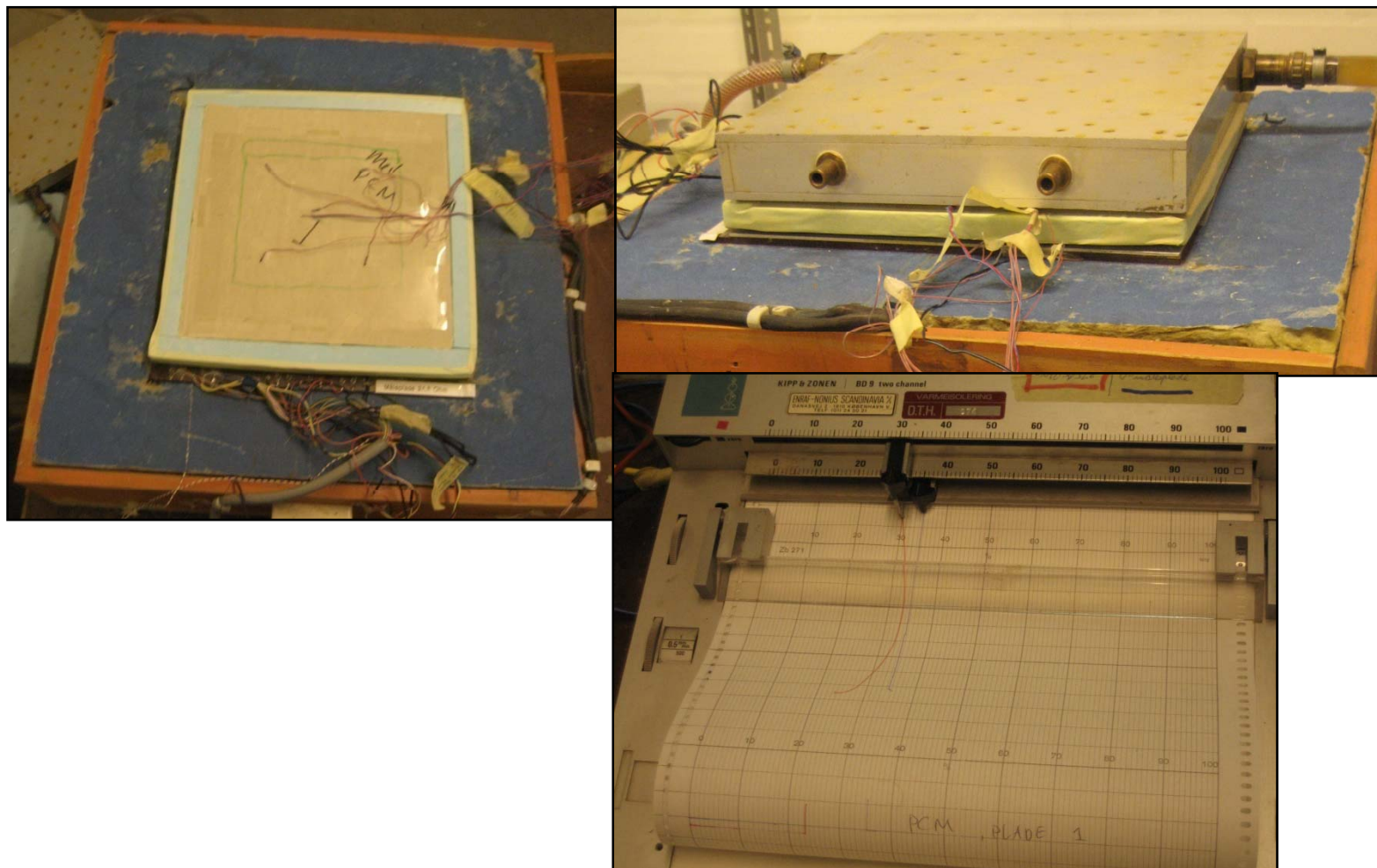


Picture: Haus der Gegenwart, Munich, Germany

# Forsøg på DTU

- Varmeledningsevne
- Varmekapacitet
- Temperaturvariation
- Temperaturvariation i rum

# Varmeledningsevne



# PCM er temperaturafhængig

- Bestemmes for temperatur under- og over smeltepunktet.
- $T_{15}$  &  $T_{30}$
- $T_{15} < \text{smeltepunkt}$ .
  - $\lambda = 0,14 \text{ W/(m}^2 \text{ K)}$
- $T_{30} > \text{smeltepunkt}$ .
  - $\lambda = 0,15 \text{ W/(m}^2 \text{ K)}$



# Varmekapacitet og entalpi

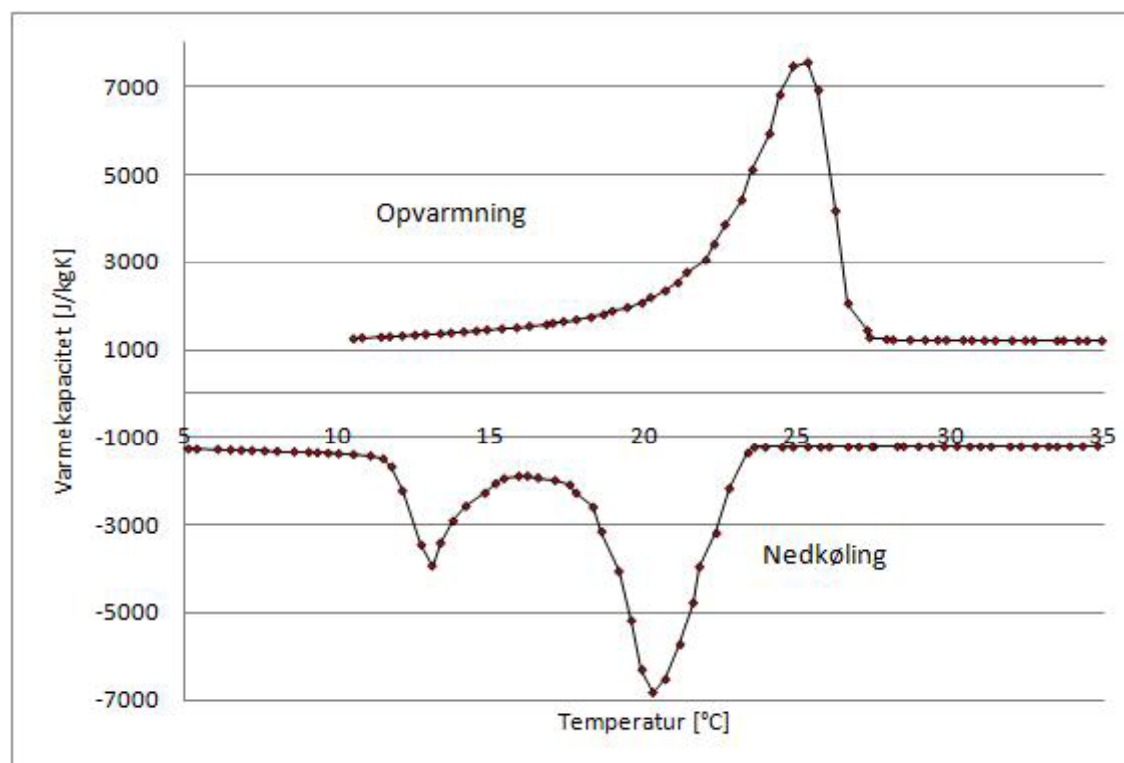


# Varmekapacitet for gips med PCM

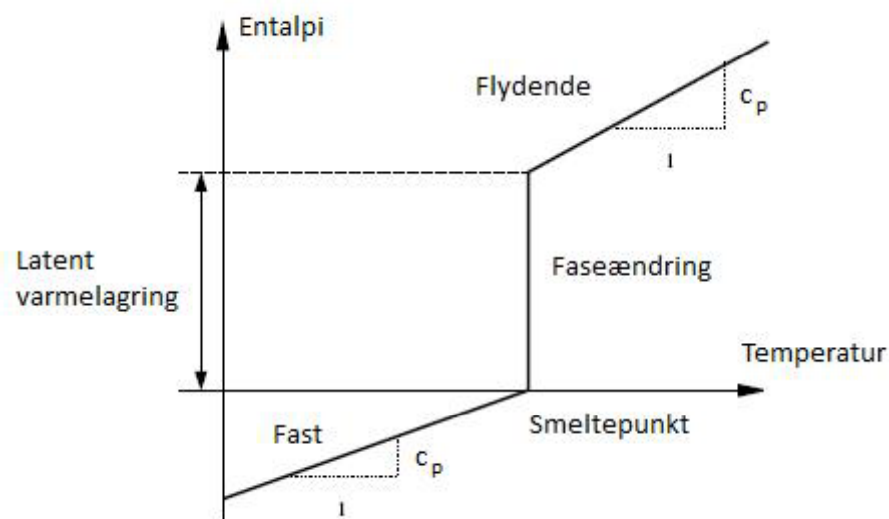




# Varmekapacitet for gips med PCM



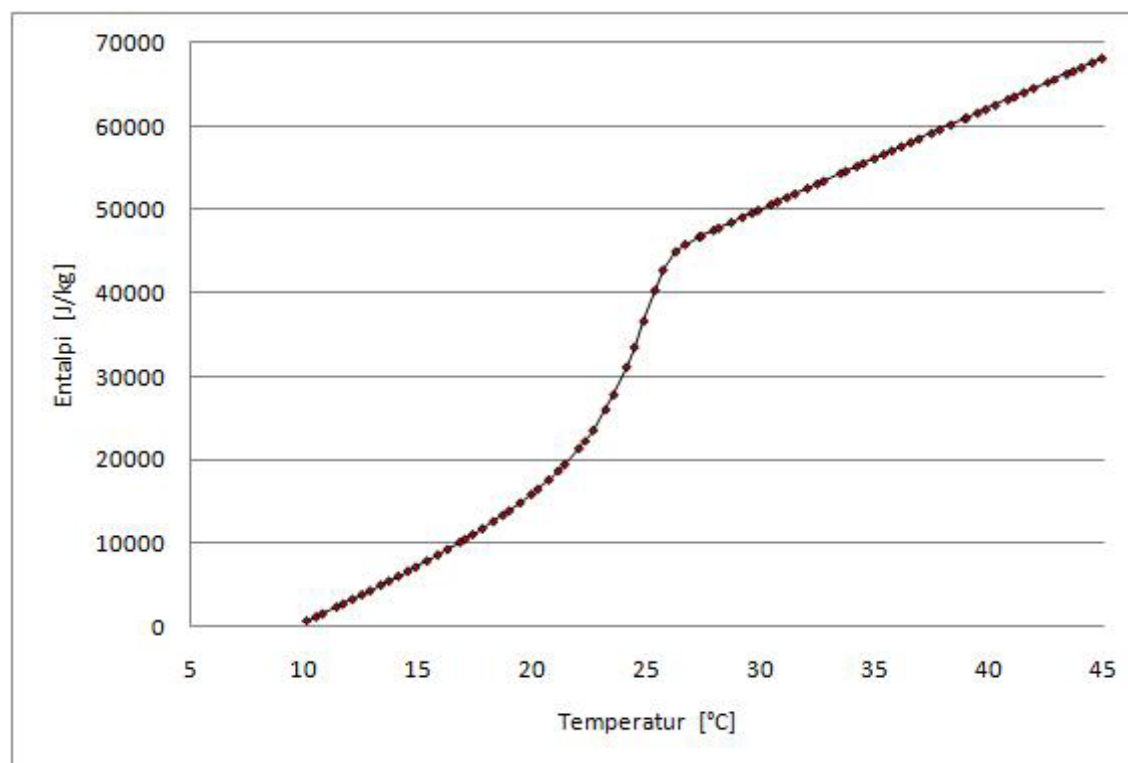
# Tilstandsfunktioner



Bestemmelse af den specifikke entalpi

$$h = h_0 + c_p (T - T_0)$$

# Entalpi for gips med PCM



# Sammenligning

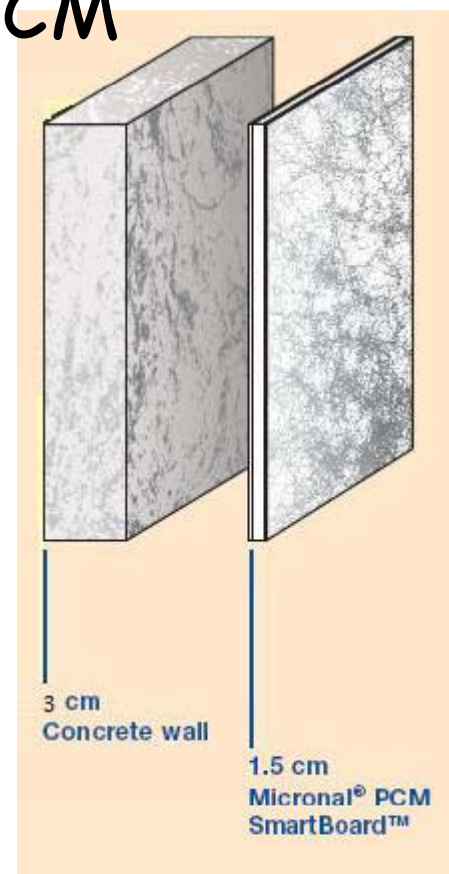
For 1m<sup>2</sup> gips på 15 mm med 30% PCM

- $\Delta H = 290 \text{ kJ/m}^2$

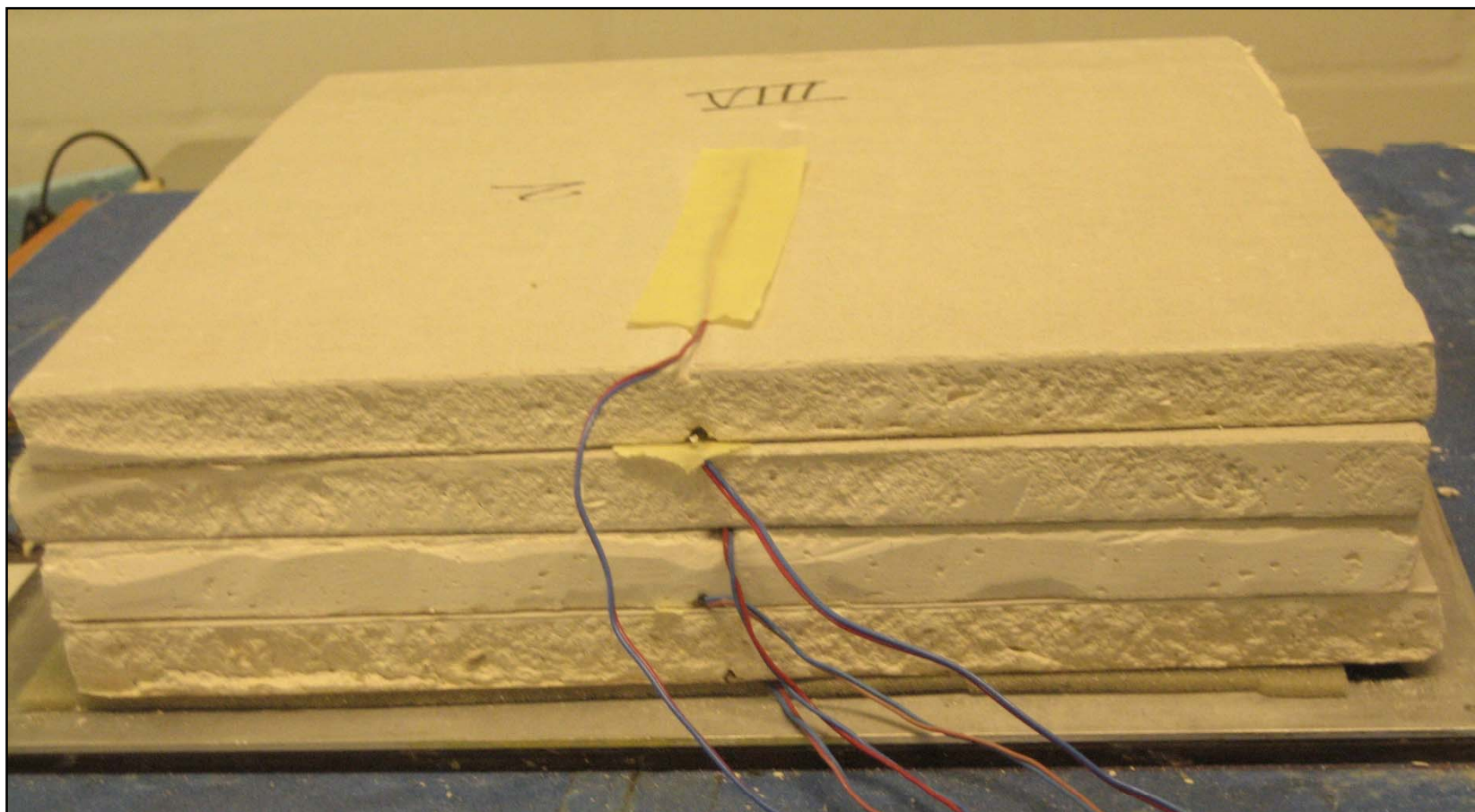
For 1m<sup>2</sup> beton på 15mm

- $\Delta H = 165 \text{ kJ/m}^2$

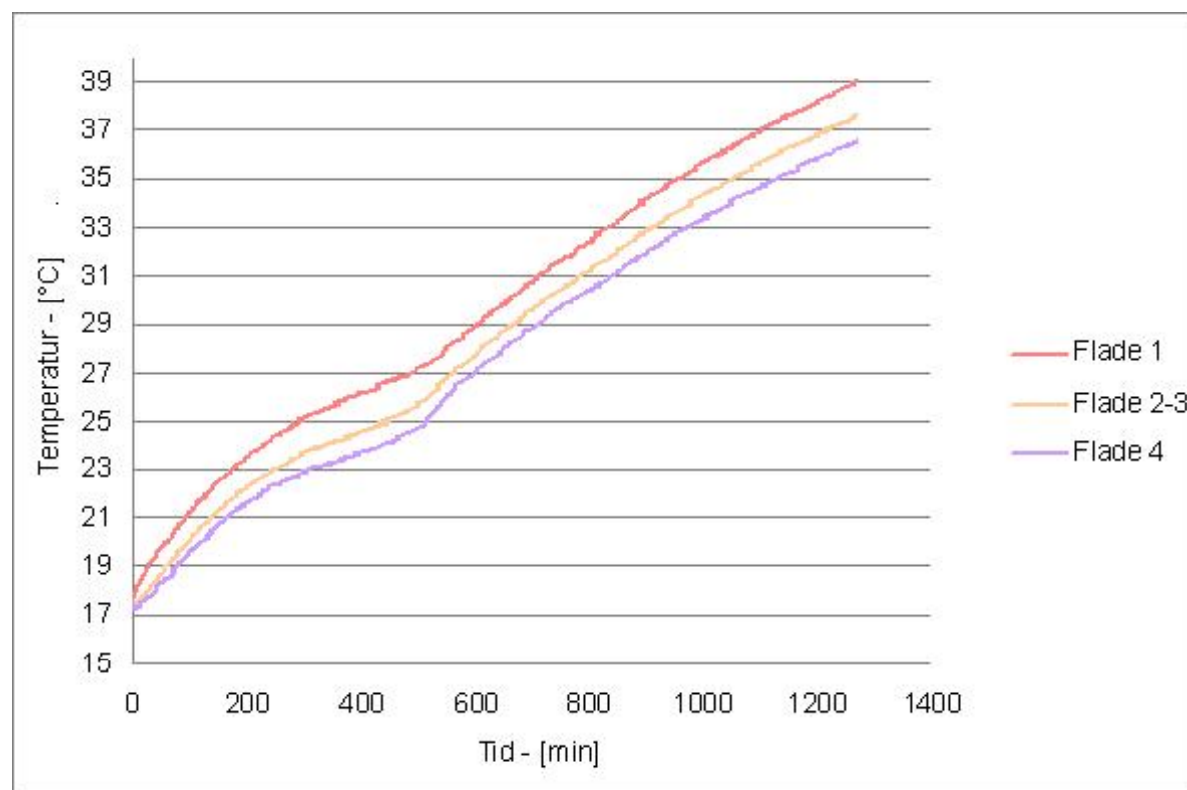
med et temperaturinterval på 5 grader



# Temperaturvariation

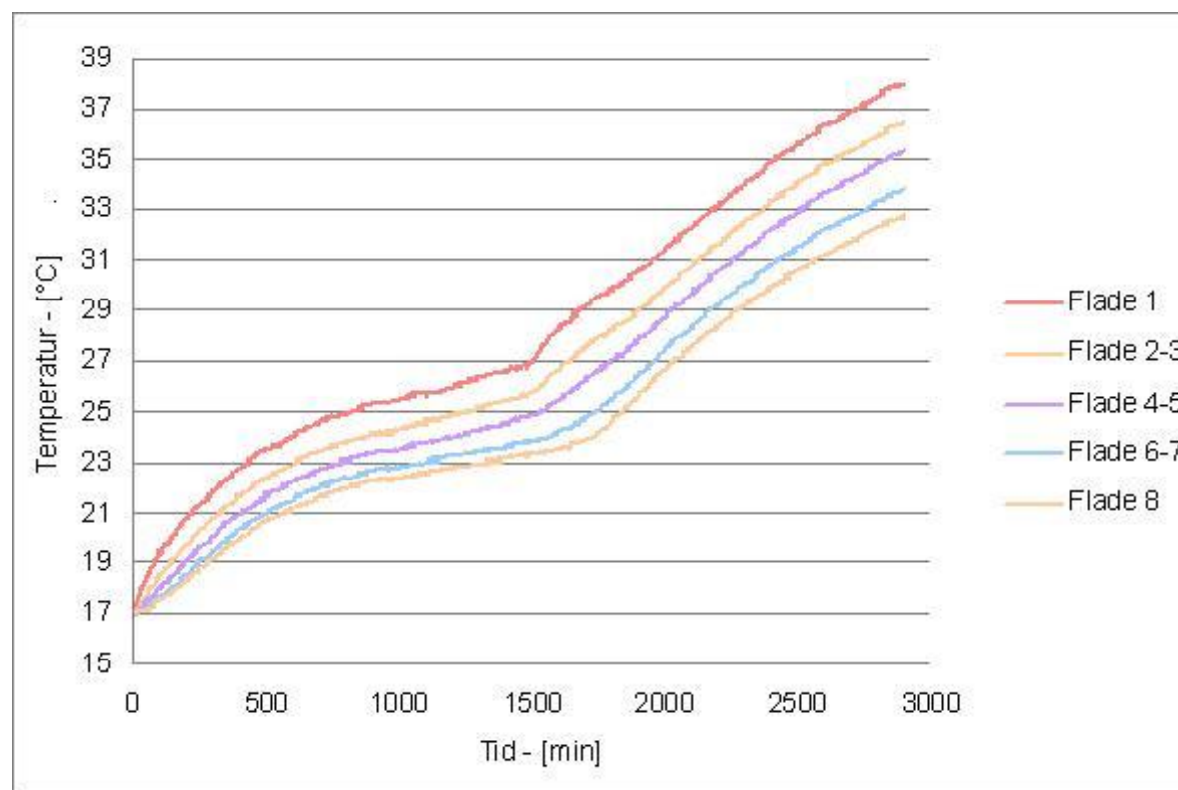


# Gips/Smartboard



Der opsættes en gipsplade på 'indersiden' af hensyn til brandfare  
Lille dæmpning ved 24 - 27 °C.

# Gips/3 Smartboards



Stor dæmpning grundet meget PCM.

# Konklusion

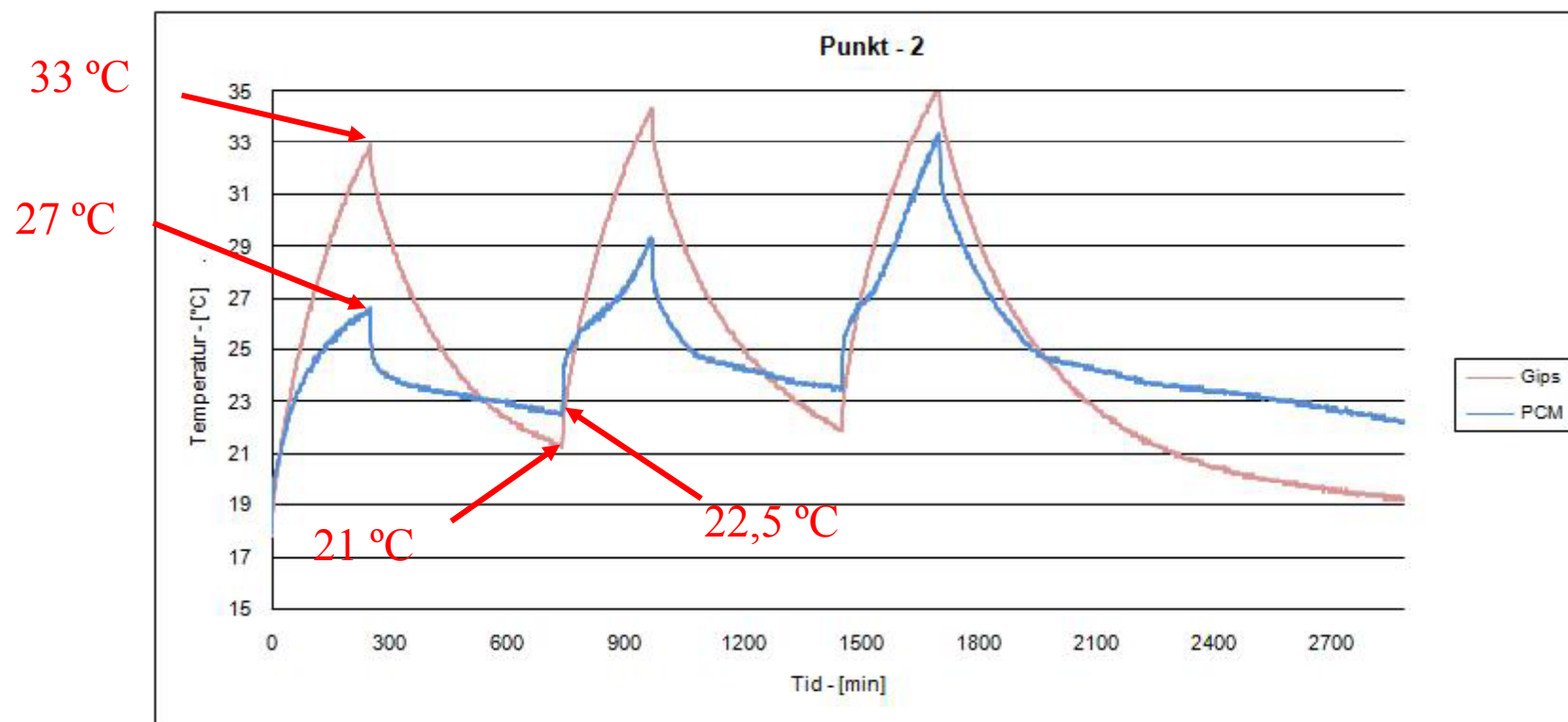
- Faseændringen sker i et interval, 22-26 °C.
- Temperaturgradient dæmpes ved faseændring → Latent varmeoptagelse.
- Dæmpning sker først ved ca. 25 °C pga. brandbeskyttende lag.



# Temperaturvariation i rum

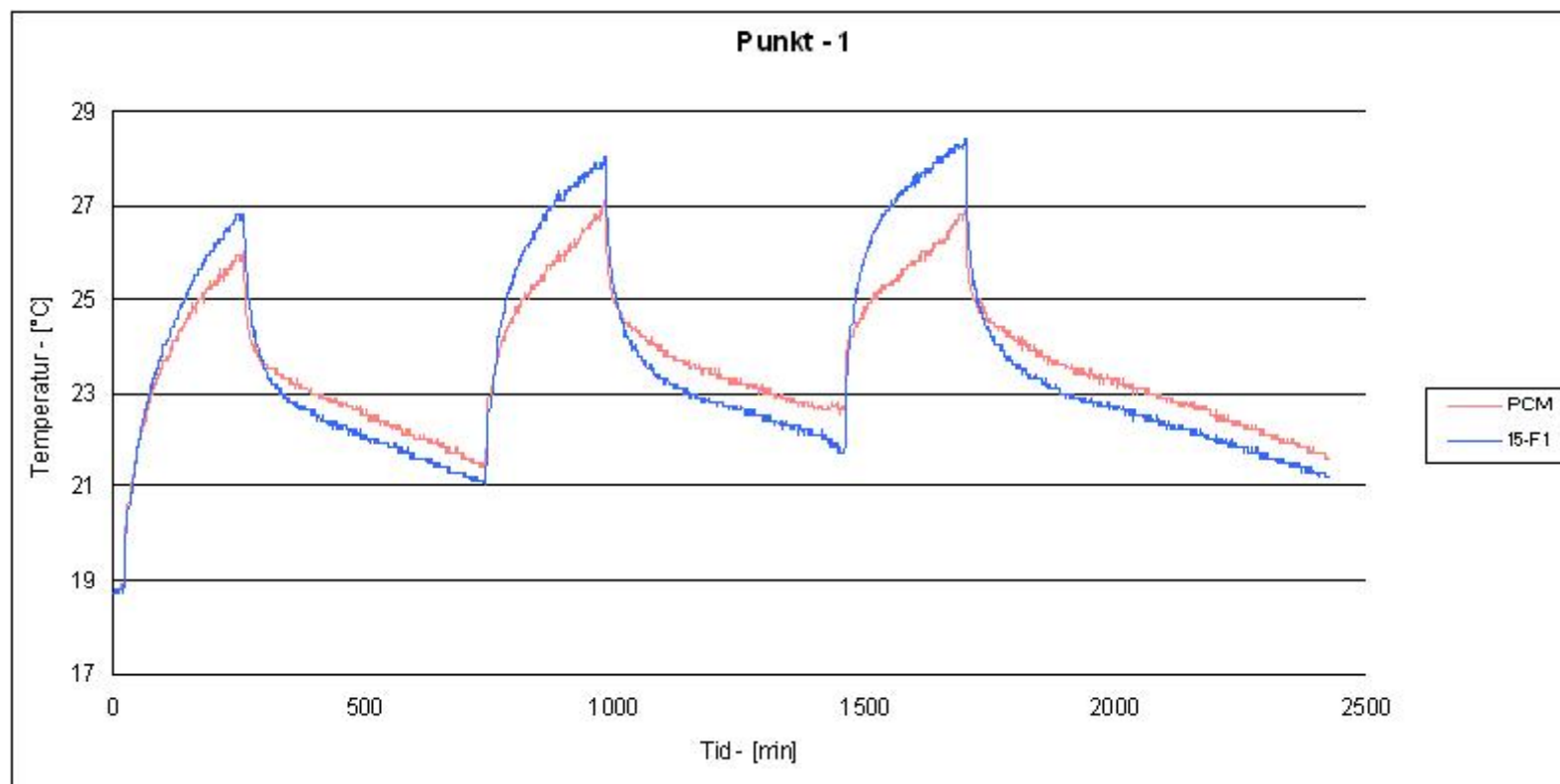


# Indvendig væg



# Brandbeskyttende lag

- Opsat et lag brandbeskyttende gips, 15-F1.



Næsten ingen forskel mellem de to rum.

# Konklusion på forsøg

- Mindre temperaturvariation ved rummet opbygget af smartboards.
- Virkning reduceres væsentligt, hvis ikke temperaturen kommer under smeltepunkt.
- Brandbeskyttende lag nedsætter PCM'ets effekt.
- Smartboards reducerer:
  - Maksimal temperatur
  - Temperaturvariation
- Temperaturen skal under smeltepunktet.

# Bygningssimuleringer med PCM

- Der er tilføjet mulighed for at lave beregninger med faseskiftende materialer i BSim
- Faseskiftende materialer kan anvendes som varmekapacitetsforøgende tilslagsmateriale i f.eks. gipsplader, porebeton, puds og beton. Anvendes materialet i f.eks. en gipsplade kan denne opnå samme termiske egenskaber som en  $\frac{1}{2}$ -stens mur.
- Faseskiftende materialer er derfor oplagt at anvende i kontorbyggeri for at undgå/reducere kølebehovet. Muligheden for at regne med faseskiftende materialer findes indtil videre som en beta-version i den seneste opdatering af BSim. Brug af den nye funktionalitet kræver at der benyttes den nyeste database (BSim2008.mdb).